INTERNATIONAL JOURNAL OF TECHNOLOGICAL EXPLORATION AND LEARNING (IJTEL)
www.ijtel.org

Design and Fabrication of Compact Size Fluidized Bed Gasifier for Automotive Vehicle

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***Abstract*— In this paper design and fabrication of compact fluidized bed gasifier with increased gas – solid interaction is proposed for automotive vehicle. The aim of the design is generate a nitrogen (N2) free product gas with low tars and fines content. Firstly a compact size gasifier with fluidized bed is designed and after that it fabricated. Design was done with the help of CATIA design/modeling software .Different particles and different size of particles was analyzed for fluidized bed. By simple geometrical modifications it is possible to achieve well mixed flow condition in the fuel/gasification reactor along the full height. The gas velocity and the geometrical properties in the fuel/gasification reactor are chosen in such a way that solid's entrainment of coarse particles in the upper part of the fuels is low at the top. Experimental results showed that achieved low ignition time as compare to packed bed gasifier.**

Keywords*- *Fluidized bed; Gasifier

I. INTRODUCTION

Direct combustion is the most common method of converting biomass resources into heat, power. A direct combustion system burns the biomass to generate hot flue gas, which is either used directly to provide heat a gasifier converts solid fuel to gaseous fuel. Introducing a gas (gas-solid systems) from the bottom of a column containing solid particles via a gas distributor can cause the particles to vibrate and expand in order to balance the drag force exerted on them by the gas stream. Upon increasing the gas velocity, a point is reached at which the drag force equals the weight of the particles and the bed is said to be fluidized.[1] A gasifier system includes the gasification reactor itself. Along with the auxiliary equipment necessary to handle the solids, gases and effluents going into or coming from the gasifier. Fluidized beds are favored by many designers for gasifier using smaller particle feedstock sizes. In a fluidized bed, air rises through a grate at high enough velocity to levitate the particles above the grate, thus forming a"fluidized bed." Above the bed itself the vessel increases in diameter, lowering the gas velocity and causing particles to recirculate within the bed itself. The recirculation results in high heat and mass transfer between particle and gas stream.[2]. A Proper design is to be implemented in gasifier for getting producer gas efficiently and compact size for using in automotive vehicles . The body of gasifier is made up of cost iron glow plug is introduced to start the combustion and the fuel is partially burnt and produce producers gases.

II. GASIFICATION

Thermochemical gasification involves the conversion of a carbonaceous feedstock such as biomass or coal at elevated temperature into a gaseous energy carrier. The gaseous product generally contains carbon monoxide, carbon dioxide, hydrogen, methane, trace amounts of higher hydrocarbons such as ethane and ethene, water, nitrogen (if air is used as the oxidising agent) and various contaminants such as small char particles, ash, tars and oils. The partial oxidation can be carried out in the presence of air, oxygen, steam or a mixture of these. If air is used as the gasification medium, a poor-quality gas is produced in terms of heating value (4-7 MJm 3 higher heating value). This type of gas is suitable for boiler, engine and turbine operation, but not for pipeline transportation due to its low energy density. A better-quality gas is produced with oxygen (10-18 MJ m 3 higher heating value) which is suitable for limited pipeline distribution and for use as synthesis gas for conversion, for example, to methanol and gasoline. Gas of this quality can also be produced by steam gasification, with the process energy being supplied by combustion of by-product char in a second reactor.

A. *Principle Of Gasification*

Gasification occurs in different steps as listed below:

- Evaporation of moisture by drying,
- Pyrolysis resulting in the production of gas, vaporised tars or oils and a solid char residue,
- Gasification or partial oxidation of the solid char, tars and gases.

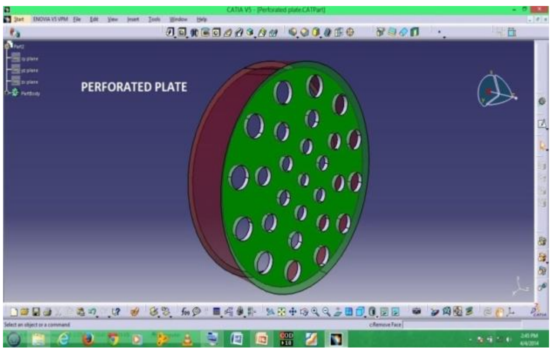

Figure 1. Perforated plate(Bed)

Subjecting a solid fuel to heated *(350500OC)* in the absence of an oxidising agent, results in pyrolyses of the fuel to solid

B. *Combustion chamber*

In this type of the gasifier above the air distribution plate there is a combustion chamber is the plenum zone where initial combustion is performed for gasifier start-up purposes. Initial combustion takes place with the help of glow plugs, it heating up the bed material and the reactor walls until a certain temperature is reached. Fuel feeding will commence once the required temperature is reached and the initial combustion process is halted.

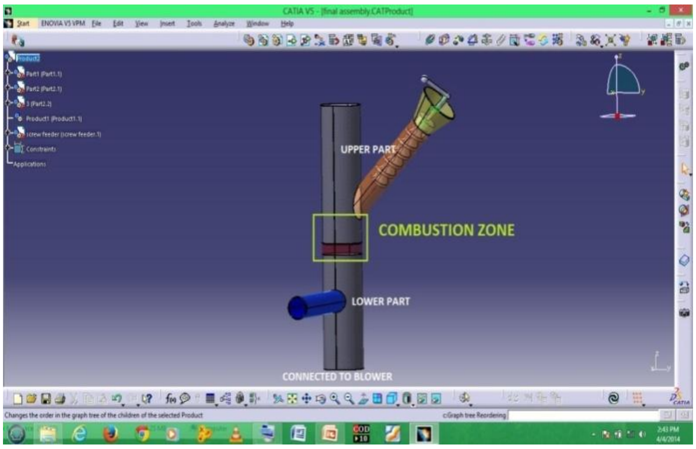

Figure 2. Gasifier

III. DIMENSION OF GASIFIER

These are the dimensions of various parts of the gasifier which is used in the design process.

TABLE I. DIMENSIONS OF COMPONENT OF GASIFIER

Component	Length(mm)	Diameter(mm)
combustion zone	95	85
gasifier pipe	914.4	85
feed pipe	304.8	55
perforated plate	2	85

IV. GASIFIER APPARATUS AND EXPERIMENTAL PROCEDURE

The gasifier assembly consists of

1. Blower of 1hp capacity to supply primary air
2. Gasifier pipe made of cast iron
3. Perforated plate which serves as grate
4. Fuel feeding system with outlet above the perforated plate.

To generate producer gas following steps should be followed

1. To start the process of gasification, first of all we place the fluidizing material over the perforated plate.
2. Thereafter, we feed approximately 180gms wood chips in the combustion chamber and manually ignite it with the help of kerosene oil.
3. The fuel is subjected to full combustion so that the bed materials (sand or chalk) will be heated to sufficient temperature required for gasification by supplying excess quantity of air through blower.
4. Quantity of air can be controlled with the help of flow control valve fitted at the lower end of gasifier pipe.
5. This process needs approximately 30 seconds after this the bed particles attain sufficient temperature.
6. Now we feed fuel continuously with feed rate of 90gm/min so that incomplete combustion takes place thereby generating producer gas (white in color).
7. We manually ignite the white cone of producer gas, to get flames

Figure 3. Actual Figure of Gasifier

V. RESULT AND CALCULATION FOR MECHANICAL POWER AND REDUCED IGNITION TIME

Ultimate analysis of organic portion of wood are:

Carbon : 50+- 3 %

Oxygen : 44+-3 %

Hydrogen : 6+-1 %

Producer gas volumetric analysis (composition) yields

CO = 20+-2 %

CH_4 = 3+-1 %

H_2 = 20+-2 %

CO_2 = 12+-1 %

N_2 = 45+-1%

The balanced chemical equation for combustion of wood is Ultimate analysis of organic portion of wood are:

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CO_2 = 12+-1 %
N_2 = 45+-1%

The balanced chemical equation for combustion of wood is-

(50/12)C+(3)H2+(44/32)O2+aO2+3.76aN2 = bCO2 + dCO + eCH4 + fH2 + gN2

a =1.7097 b=1.7143 e=0.0714 d=2.8572 f=2.8572 g=6.4286

Mass of fuel gas produced = 3.35kg/kg of wood

Calorific value of producer gas = 4.75 MJ/kg

Wood consumption rate = 5.4 kg/hr

Gases produced by wood = 3.35*5.4kg/hr

= 18.09kg/hr

Heating value = 18.09kg/hr* 4.75 * 1000kJ/kg of gases produced

= 85927.5 kJ/hr

= 23.8687 kJ/sec

Mechanical power = 7.16KW (by taking 30% combustion + mechanical efficiency)

Superficial velocity = Gas Production Rate / (Cross sectional area of gasifier* density)

SV = 0.886m/s (density = 1kg/cubic meter)

VI. APPLICATION

As mentioned earlier the main applications of biomass gasifier are:

- Shaft power systems
- Direct heat applications
- Chemical production

In the shaft power systems the main agriculture applications are driving of farm machinery like tractors, harvesters etc. There are quite a number of manufacturers catering to the on-farm machinery gasification systems. [3] Small scale electricity generation systems also provide an attractive alternative to utilities.

Another useful application of producer gas units is in irrigation systems. This seems to be the most to be the most important application in developing countries. [4] There is no reason why such systems cannot become popular in developed countries especially when there have been quite a number of solar powered irrigation systems installed.[5] Direct heat systems, because of their simplicity, may prove to have biggest applications in agriculture. Among them are grain drying, green house heating and running of absorption refrigeration and cooling systems. Again these systems can be coupled to other renewable energy systems like solar for thermal applications. Another interesting application for direct heat (external combustion) application is running of Stirling engines.[6] These engines have very high efficiencies and may prove to be a better alternative than internal combustion engine running on producer gas.

Production of chemicals like Methanol and Formic acid from producer gas is a recent phenomenon.[7] However with fossil fuels getting scarcer, production of these chemicals by producer gas may prove to be an economically feasible proposition. Another interesting application may be use of producer gas to run a fuel cell plant. The energy density of such a plant would be highly favorable as compared to IC engine systems.

However for all these applications the most important ingredient is the availability of biomass fuel. For on farm applications biomass residues are attractive proposition. However, before any large scale application of gasification is undertaken the fuel availability is to be critically ascertained. As an example it is instructive to look at the land area required, for a gasifier to run on cotton stalks (biomass residue) as fuel. On an average, quantity of stalks harvested is 1.5 tons/acre/yr.[8] Thus a 100 kW gasifier running at 8 hours per day for 300 days/year will require about 213 acres of cotton plantation to produce the required cotton stalks. Against such background all the future applications of gasifiers should be evaluated.

If the biomass residue availability is not adequate then the decision has to be made about running it on wood. However such decisions can only be made at specific sites and for specific applications. Just like in any other alternative energy source it is advisable to use hybrid systems, similarly in biomass gasifications systems also it will be worthwhile to use them in conjunction with other energy systems. For example, grain drying can have biomass gasifier/solar coupling.

VII. CONCLUSION

The device has been developed based on the dimensions that are specified and preliminary trials for fluidization of the particles is carried out. The glow plugs are used for initiating the combustion inside the chamber.

- Biomass gasification offers the most attractive alternative energy system for agricultural purposes.
- Most preferred fuels for gasification have been charcoal and wood. However biomass residues are the most appropriate fuels for on-farm systems and offer the greatest challenge to researchers and gasification system manufacturer
- Very limited experience has been gained in gasification of biomass residues.
- Most extensively used and researched systems have been based on downdraft gasification. However it appears that for fuels with high ash content fluidized bed combustion may offer a solution. At present no reliable and economically feasible systems exist.
- Biggest challenge in gasification systems lies in developing reliable and economically cheap cooling and cleaning trains.
- Maximum usage of producer gas has been in driving internal combustion engine, both for agricultural as well as for automotive uses. However direct heat applications like grain drying etc. are very attractive for agricultural systems.
- A spark ignition engine running on producer gas on an average produces 0.55-0.75 kWh of energy from 1 kg of biomass.
- Compression ignition (diesel) engines cannot run completely on producer gas. Thus to produce 1 kWh of

energy they consume 1 kg of biomass and 0.07 liters of diesel. Consequently they effect 80-85% diesel saving.

Future applications like methanol production, using producer gas in fuel cell and small scale irrigation systems for developing countries offer the greatest potentialities.

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